

Diagnostics for Laser-Driven Equation of State Experimentss

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The recent measurements of the equation of state (EOS) of liquid deuterium along the principal Hugoniot up to a pressures of 2 Mbar (200 GPa) utilized a set of new diagnostics developed specifically for laser-driven EOS experiments[1]. These experiments utilized a high power smoothed laser beam to directly shock the D_2 sample. Absolute EOS data were obtained by using temporally resolved radiography to measure both the particle speed and the shock speed in the D_2 . For this experiment, a high-spatial-resolution x-ray microscope was designed and built.[2] The microscope provided a resolution of a few microns at an 800 eV photon energy.

The microscope was just one instrument that was required. In order to obtain EOS data with small uncertainties when using lasers to drive strong shocks, it is necessary to confront several potential problems. Lasers can drive very strong shocks but the spatial dimensions of the laser spot are small. This makes it necessary to characterize the planarity of the shock. In addition, high intensity lasers typically produce kilovolt temperatures in the laser deposition region. This region can be a source of high energy x rays and suprathermal electrons that can enter the sample prior to arrival of the designed shock, thus preheating the sample and confounding the results. In order to assess both shock planarity and sample preheat in the D_2 experiments, we designed and installed an interferometer to monitor the rear face of the pusher that provided the shock to the D_2 . Figure 1 shows an interferogram from that experiment.

In the D_2 experiment we were able to measure shock speeds with $\sim 3\%$ uncertainty. In order to increase the precision of this measurement we have considered using a velocity interferometer (VISAR) to track the shock the sample.

D_2 or H_2 shocked into the Mbar regime is expected to be heated to approximately 1-2 eV. The Hugoniot data obtained in the D_2 experiment[1] do not contain any temperature information. Relying on the large bandgap of liquid D_2 and H_2 , we have designed a diagnostic to measure the emissivity from a shocked liquid sample and determine a brightness temperature of the shocked liquid.

These diagnostics will be fielded on a set of laser-driven EOS experiments for liquid hydrogen and deuterium. The new experiments will be conducted in the regime up to 3 Mbar. Results from these diagnostics will be reported and discussed. Implications for future laser-driven EOS experiments will be considered.

Work performed under the auspices of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

References

- [1] L.B. Da Silva et al. *Phys. Rev. Lett.* **78**, 483(1997).
- [2] L.B. Da Silva et al., "Equation of State Measurements of Liquid Deuterium and Hydrogen up to 3 Mbar," presented at this conference.

